Optical device for recording and reproducing

FIELD OF THE INVENTION

The present invention relates to an optical scanning device for scanning an information carrier comprising tracks, said optical scanning device comprising means for compensating for spherical aberration.

The present invention is particularly relevant for an optical disc apparatus for recording to and reading from an optical disc, e.g. a CD, a DVD and/or a Blu-Ray Disc (BD) recorder and player.

BACKGROUND OF THE INVENTION

Many optical scanning devices require means for compensating for spherical aberration. Actually, information carriers are often scanned by an optical scanning device through a transparent layer protecting an information layer. A small variation of the thickness of the transparent layer causes a substantial change in the spherical aberration incurred by a high-numerical aperture radiation beam passing through the transparent layer. Spherical aberration compensation is also needed for scanning a multilayer information carrier, because the spacer layer between two layers generates spherical aberration when jumping from one layer to the other. Spherical aberration compensation is also needed for scanning different types of information carrier having different cover layer thicknesses.

Various spherical aberration compensation means are known. A first example is a liquid crystal cell placed in the optical path. Spherical aberration is introduced in the radiation beam in that the index of refraction of the liquid crystal cell is locally changed by application of a voltage over the liquid crystal cell. A second example is a compensating plate placed between two lenses. When spherical aberration needs to be introduced in the radiation beam, the compensating plate is placed in the optical path, whereas it is mechanically removed from the optical path when no spherical aberration is needed. Other examples are known, such as a birefringent replicated polymer phase plate.

Moreover, use of split optics is often required in many optical scanning devices. Optical scanning devices using split optics comprise a fixed part comprising, inter alia, the radiation source, and a movable part comprising a folding mirror and an objective lens. The use of split optics simplifies the optical scanning device and increases the radiation source life, because a heat sink can be placed in the vicinity of the radiation source, as the latter is fixed.

An optical scanning device implementing split optics and comprising means for compensating for spherical aberration comprises a fixed part with a radiation source and means for compensating for spherical aberration, and a movable part comprising a folding mirror and an objective lens. The optical scanning device further comprises means for moving the movable part in a cross track direction so as to achieve track selection. It also comprises means for moving the objective lens in a cross track direction so as to achieve fine tracking, in order to ensure that the radiation beam remains focused on a track, whatever the eccentricity of the information carrier.

However, the applicant has noted that in such an optical device, a large amount of coma is generated during tracking.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an optical scanning device comprising split optics and means for compensating for spherical aberration, in which optical scanning device the amount of coma generated during tracking is reduced.

To this end, the invention proposes an optical scanning device for scanning an information carrier comprising tracks, said optical scanning device comprising a fixed part with a radiation source and means for compensating for spherical aberration, and a movable part comprising a folding mirror and an objective lens, the optical scanning device comprising first moving means for moving said movable part in a cross track direction in a track selection mode, and second moving means for moving said objective lens in a cross track direction in a fine tracking mode and for moving said folding mirror in said fine tracking mode such that said folding mirror substantially follows said objective lens.

The applicant has noted that the coma generated during tracking is due to the fact that the centre of the means for compensating for spherical aberration does not remain aligned with the center of the objective lens in the optical path. According to the invention, the radial position of the folding mirror with respect to the radial position of the objective lens always remains the same. The radial position is the position in the cross track direction. The centre of the spherical aberration compensation means accordingly remains aligned with the centre of the objective lens. The coma is thus eliminated during tracking.

In a first embodiment, the second moving means are adapted to move said movable part in said fine tracking mode. According to this embodiment, no radial actuator is used for moving the folding mirror or the objective lens. The movable part itself is moved during tracking. The optical scanning device is thus relatively simple.

In a second embodiment, the second moving means comprise a first actuator for moving said objective lens and a second actuator for moving said folding mirror. This embodiment is preferred when the movable part cannot be moved during tracking, which may be the case if the weight supported by said movable part is too large.

Advantageously, the optical scanning device further comprises means for detecting the position of the objective lens and means for sending a signal representative of said position to said second actuator. This allows controlling the radial position of the folding mirror with respect to the radial position of the objective lens with a relatively high accuracy.

Preferably, the first and second actuators are controlled by a same tracking signal. In this case, no means for detecting the position of the objective lens are needed, which simplifies the optical scanning device.

These and other aspects of the invention will be apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail by way of example with reference to the accompanying drawings, in which :

- Fig. 1 shows an optical scanning device in accordance with the prior art;
- Fig. 2 shows a portion of the optical scanning device of Fig. 1 during tracking;
- Fig. 3 shows an optical scanning device in accordance with a first embodiment of the invention;
- Fig. 4 shows an optical scanning device in accordance with a second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

An optical scanning device in accordance with the prior art is depicted in Fig. 1. This optical scanning device comprises a fixed part 10 and a movable part 11. The fixed part 10 comprises a radiation source 101, a beam splitter 102, a collimator lens 103, spherical aberration compensation means 104, a servo lens 105 and detecting means 106. The movable part 11 comprises a folding mirror 111 and an objective lens 112. This optical device is intended for scanning an information carrier 12.

During a scanning operation, which may be a writing operation or a reading operation, the information carrier 12 is scanned by the radiation beam produced by the radiation source 101. The collimator lens 103 and the objective lens 112 focus the radiation

beam on an information layer of the information carrier 12. A focus error signal may be detected, corresponding to an error of positioning of the radiation beam on the information layer. This focus error signal is detected by the detecting means 106 and may be used for correcting the axial position of the objective lens 112, so as to compensate for a focus error of the radiation beam. To this end, a controller drives an actuator in order to move the objective lens 112 axially, i.e. with a movement noted F perpendicular to the information carrier.

The information carrier comprises tracks on which data is recorded. In order to scan a given track, the radiation beam has to be focused on said given track. To this end, the movable part 11 is moved in the cross track direction with a movement noted S, such that the radiation beam reaches the desired track. This corresponds to a track selection mode, wherein the movable part is moved in a cross track direction until the radiation beam is focused on the desired track. Once the radiation beam is focused on the desired track, the radiation beam should remain focused on said track during a rotation of the information carrier 12. However, the information carrier exhibits eccentricity. The objective lens 112 is thus moved such that the radiation beam remains focused on the track. This corresponds to a tracking mode, wherein the objective lens is moved in the cross track direction with a movement noted T such that the radiation beam remains focused on a desired track.

The movable part is usually moved by means of a linear motor in the track selection mode, whereas the objective lens 112 is usually moved by means of an actuator in the tracking mode. The actuator is controlled by a tracking signal indicating the difference between the position of the radiation beam and the centre of a track. Track selection and tracking are known to those skilled in the art and will not be described further.

Fig. 2 shows a portion of the optical scanning device in accordance with the prior art, in the tracking mode. As is shown in Fig. 2, a displacement of the objective lens 112 during tracking leads to the fact that the centre of the spherical aberration compensation means 104 does not remain aligned with the centre of the objective lens 112 in the optical path. The applicant has noted that coma is generated in this situation. This would not happen without spherical aberration compensation means 104. Actually, the generation of coma is due to the introduction of a wavefront aberration in the radiation beam by the spherical aberration compensation means 104, combined with the decentring of the objective lens 112 with respect to the spherical aberration compensation means 104.

An optical scanning device in accordance with a first embodiment of the invention is depicted in Fig. 3. In this Fig., numbers identical to numbers of Fig. 1 stand for the same elements. According to this first embodiment, the folding mirror 111 and the objective lens 112 are attached to the movable part 11, such that no radial displacement is possible between the movable part 11 and the objective lens 112. This means that, compared with the optical scanning device of the prior art, the optical scanning device of Fig. 3 does not comprise any radial actuator that moves the objective lens in a cross track direction during tracking. Instead, moving means are used during tracking so as to move the movable part 11 in the cross track direction with the movement T. These moving means may be the moving means used for moving the movable part 11 in the cross track direction in the track selection mode. For example, a linear motor used for moving the movable part 11 in the track selection mode may be used in the tracking mode. This linear motor should have a relatively large stroke for moving the movable part 11 during track selection, and a relatively high bandwidth for moving the movable part 11 in the tracking mode. Alternatively, the moving means used for moving the movable part 11 in the tracking mode may comprise a one-dimensional radial actuator. Examples of suitable one-dimensional actuators are a linear electromagnetic actuator and a piezo-ceramic actuator, which are well known to those skilled in the art. This one-dimensional radial actuator should have a relatively high bandwitdth for moving the movable part 11 in the tracking mode. This is possible in an optical scanning device using split optics, where the total weight of the movable part is relatively low compared with the total weight of a sledge in an optical device which does not use split optics.

According to this first embodiment, the radial position of the folding mirror 111 always remains the same with respect to the radial position of the objective lens 112, because the objective lens 112 and the folding mirror 111 can only move together with the movable part 11 in the radial direction. The decentring that occurs during tracking in the prior art, as shown in Fig. 2, thus does not occur anymore in the optical scanning device in accordance with this first embodiment of the invention. As a consequence, no coma is generated during tracking in accordance with this first embodiment of the invention.

It should be noted that the optical scanning device in accordance with this first embodiment of the invention is also simpler than the optical scanning device in accordance with the prior art. In the optical scanning device of the prior art, a two-dimensional actuator is attached to the movable part 11 for moving the objective lens 112 with the respective movement F and T. In the optical scanning device in accordance with this first embodiment, a one-dimensional actuator can be attached to the movable part 11 so as to move the

objective lens 112 with the movement F. A one-dimensional actuator is simpler, less bulky and cheaper than a two-dimensional actuator.

An optical scanning device in accordance with a second embodiment of the invention is depicted in Fig. 4. In this Fig., numbers identical to numbers of Fig. 1 stand for the same elements. According to this second embodiment, the movable part 11 comprises a first and a second actuators, not shown in Fig. 4. The first actuator is designed for moving the objective lens 112 in a cross track direction in the tracking mode with a movement T1 and the second actuator is designed for moving the folding mirror 111 in a cross track direction in the tracking mode with a movement T2. The first actuator may be a two dimensional actuator which is designed for moving the objective lens 112 with the movement T1 and with the movement F. Alternatively, another one dimensional-actuator may be used for moving the objective lens 112 with the movement F.

According to this second embodiment of the invention, the movements T1 and T2 are substantially the same. The radial position of the folding mirror 111 accordingly always remains substantially the same with respect to the radial position of the objective lens 112. The decentring that occurs during tracking in the prior art thus does not occur or has no influence in the optical scanning device in accordance with this second embodiment of the invention. As a consequence, no coma is generated during tracking in accordance with second embodiment of the invention.

In order to ensure that the movement T2 is substantially the same as the movement T1, i.e. that the folding mirror 111 follows the radial movement of the objective lens during tracking, a first method consists in measuring the radial position of the objective lens 112 during tracking. Depending on said measured position with respect to the position of the folding mirror 111, a signal is sent to the actuator moving the folding mirror 111, such that the folding mirror is moved until it reaches the same radial position as the objective lens 112.

A second method consists in controlling the second actuator with the same signal as the signal controlling the first actuator. As explained in Fig. 1, conventional optical scanning devices comprise means for generating a tracking signal, which is sent to the actuator moving the objective lens so as to move the objective lens during tracking. This tracking signal is representative of the difference between the position of the radiation beam and the centre of a track. This tracking signal is obtained, for example, by means of the so-called 3 spots push-pull tracking method. If the actuator that moves the folding mirror 111 is controlled by the

same signal as the actuator that moves the objective lens 112, the folding mirror 111 will have the same movement as the objective lens 112.

Any reference sign in the following claims should not be construed as limiting the claim. It will be obvious that the use of the verb "to comprise" and its conjugations does not exclude the presence of any other elements besides those defined in any claim. The word “a” or “an” preceding an element does not exclude the presence of a plurality of such elements.